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14 What makes them leave and where do they go? Non-completion and institutional departures in STEM

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Abstract This chapter presents the results of a quantitative analysis of national data covering Danish students who in the period 1995-2009 completed an upper-secondary school programme and entered a higher-education science, technology, engineering or mathematics (STEM) programme. The analysis focuses on identifying variables that change the hazard ratio for (1) entering a STEM programme and (2) leaving a STEM programme without completing it. Finally, the chapter explores (3) the destinations of students who leave a STEM higher-education programme. It is found that there has been no change in the relative chance of a male or female student entering a STEM programme. The results suggest that female students are more affected by achieving a high grade-point average and by the educational background of their parents than are the male students. The relative risk of non-completion is higher for women than for men, but the most important factor is GPA on entry. A disturbing result is that when student leave a STEM programme, only one third enter another STEM programme. Slightly more enter a non-STEM programme while non-STEM leavers only rarely enter a STEM programme. Non-completion in STEM higher education is a net loss of STEM graduates.

Keywords: Dropout, Attrition, Retention, Stayers, Leavers, pre-entry attributes

Introduction

Other chapters in this book point to the importance of identity in order to understand the complexity of the process of students' choices and experiences. However, it is also relevant to consider aspects of recruitment and retention on a larger scale. Therefore, this chapter adopts a macroscopic approach. It does so with three purposes. The first purpose is to examine whether there have been changes in the patterns of recruitment and retention of male and female STEM students during the past 10-15 years. This is significant considering the number of research and policy documents published in that period of time (see Chapter 1 in this book for references on policy documents and Chapters 2, 3 and 5 for research). The second purpose is to explore whether different factors affect the behaviour of men and women differently in relation to entering and staying in higher-education STEM programmes. The third purpose is to explore what happens to the students who decide to leave their STEM higher-education programme without completing. The focus of the chapter will be on overall trends and on gender differences.

Using national data from Denmark, the chapter addresses three questions:

1. *Changing patterns in students' choices*: Have the patterns of men's and women's choice of STEM changed over time?
2. *Risks of non-completion*: Are there differences in the risk of not completing the STEM programme the students have entered according to gender, and do different factors affect the risk of non-completion for male and female students?
3. *Departure trajectories*: Where do students go if the leave their STEM programme without completing it?

The study is longitudinal in two respects. First, it studies the students' trajectories by not only looking at the students' first choice of study after finishing high school, but also whether they complete the study or not, and, in case they leave the study without completing it, what choice of study (or not) they make thereafter. Second, it studies the patterns of choice over time to see whether the patterns have changed during the period 1995-2009. Hence, the study is longitudinal on both an individual level and concerning the patterns that are found.

The sample

The method of analysis will be presented as we address the three questions. In this section we will present the data the analysis builds upon.

The data used is retrieved from Statistics Denmark, the official statistical bureau of Denmark that receives data from, among others, all Danish educational institutions. Due to the Danish registration policy it is possible to track individuals over time, to combine data from different sources concerning the same individual, and to link individuals to their parents and to data concerning the parents.

After nine years of compulsory schooling, young people need to decide whether they wish to pursue vocational training for a trade (for instance, carpenter, secretary, or car mechanic) or a non-vocational upper-secondary school preparing for higher education (in Danish: gymnasium). The analysis in this chapter covers all students who in the period 1995-2009 graduated from the non-vocational upper-secondary school in Denmark. The 15 year group were clustered in three cohorts:

1995-1999, 2000-2004 and 2005-2009. Note that a particular year refers to the year the student completed upper-secondary school, *not* the year of entrance at the higher-education programme. Therefore, numbers regarding, for instance, distribution of students at different programmes may differ from other statistics on STEM entrance that usually use the year of entry as reference.

The sample of all students completing gymnasium in the 15 year period consists of 464,607 students (58 % women) (Table 14.1). Not all of these students continued to higher education or to a STEM study programme.

Table 14.1 Number of students in the three cohorts and the gender distribution

	Year of completing upper-secondary school					
Sex	1995-1999		2000-2004		2005-2009	
	Number	%	Number	%	Number	%
Men	67,142	41.6	59,627	41.8	68,427	42.6
Women	94,140	58.4	83,057	58.2	92,214	57.4
Total	161,282	100.0	142,684	100.0	160,641	100.0

In addition to information concerning students' enrolments on study programmes at Danish institutions, a number of background variables were included in the analysis:

- Sex[1]
- Origin: Danish; Immigrant; Descendant (i.e. a person born in Denmark whose parents are either immigrants or descendants with foreign citizenship).
- Highest acquired education of the parents when the student was 13 years old.
- The specialisation (or line) of gymnasium (general (stx), commercial (hhx), technical (htx) or higher preparatory (hf))
- Grade-point average (GPA) for upper-secondary school.
- Number of gap years in total.
- Number of years spent at another higher education programme before entering the first STEM programme.

[1] The data uses the biological sex as a means of distinction. In our analysis we use the phrase 'gender' because the behaviour behind the data is, inter alia, a result of gendered practices (see chapter 4 about the distinction between sex and gender).

In the present analysis, we focus on gender while other variables are only included to a limited extent.

Groups of educational programmes

We divided the higher education programmes that students could enter into STEM and non-STEM programmes. Health programmes (including medicine and the pharmaceutical sciences) were in this analysis considered non-STEM studies because they do not suffer from the same recruitment or retention difficulties as do STEM programmes. Neither do the veterinary sciences, but for institutional reasons (that is, where the programme is offered in Denmark) we decided to include them in the group of STEM programmes.

Next, we distinguished between STEM programmes aiming at Masters level at universities (usually aiming at five-year programmes), and professional bachelor programmes at university colleges (completed after three or four years). At the university level we divided the programmes into two: science and university engineering. In this chapter, when we present results for STEM as a whole, all STEM studies are included.

The university sciences (18 sub-disciplines; 26,072 students) include programmes such as biology, chemistry, physics and mathematics. The university engineering programmes (nine sub-disciplines; 13,701 students) include sub-disciplines such as construction, environmental engineering, chemical engineering and nano-technology. Professional engineering programmes (nine sub-disciplines; 15,452 students) include sub-disciplines in structural engineering, environmental engineering and construction.

The number of students entering each of the remaining STEM programmes is too small for robust statistical analysis (even though between 18 % and 15 % of STEM students attend these programmes) and the programmes are too diverse to allow for grouping.

The extraction and analysis of the data was performed by UNI-C Statistics & Analysis, an agency of the Danish Ministry of Education[2].

[2] We are grateful for the help and assistance in the design, execution, and interpretation of the analysis we have received from Claus Jensen and Tine Høtbjerg Henriksen (UNI-C) and Professor Svend Kreiner (University of Copenhagen).

Results (i): Changing patterns in students' educational choice

The first analysis was done as a simple distribution of the students between different types of studies. The number of students who entered a STEM or non-STEM programme was calculated as a percentage of the total number of students completing upper-secondary school. Note that the number refer to the first time a student entered a STEM programme. A student who first entered a non-STEM programme and then a STEM programme will appear twice, whereas a student who first entered one and then another STEM programme appears only once. The results therefore show the share of students in each set of cohorts who at some time entered a STEM programme and the number who at some time entered a non-STEM programme (Table 14.2).

The decrease in the number of students from the third cohort (2005-2009) who have entered any higher-education programme at all reflects the large group of students who take one or two gap years between upper-secondary school and higher education. According to the Danish Ministry of Science, Innovation and Higher Education only 24% of the students entering universities in 2012 came straight from upper-secondary school, and 20% had taken three or more gap years before entering (Ministeriet for Forskning Innovation og Videregående Uddannelser, 2012). A significant group of students in this cohort therefore have not yet entered the programme they wish to pursue, but may do so later.

Table 14.2 Students entering STEM or non-STEM higher education programmes after upper-secondary school. The percentage refers to the total number of students completing gymnasium. That is of the 61,142 men completing upper-secondary school 1995-99, 24.5 % (16,433) entered a STEM programme.

	1995-99		2000-04		2005-09		
	Number	Pct.	Number	Pct.	Number	Pct.	
STEM	Men	16,433	24.5%	14,940	25.1%	11,659	17.0%
	Women	8,533	9.1%	8,053	9.7%	6,684	7.2%
	Total	24,966	15.5%	22,993	16.1%	18,343	11.4%
Non-STEM	Men	32,402	48.3%	29,137	48.9%	21,619	31.6%
	Women	61,454	65.3%	56,560	68.1%	42,599	46.2%
	Total	93,856	58.2%	85,697	60.1%	64,218	40.0%
Total entrants	Men	48,835	72.7%	44,077	73.9%	33,278	48.6%
	Women	69,987	74.3%	64,613	77.8%	49,283	53.4%
	Total	118,822	73.7%	108,690	76.2%	82,561	51.4%

Overall, there appears to be no, or a very small, increase in the share of students entering a STEM higher education programme (from 15.5 in the first to 16.1 % in the second cohort). The relative popularity of STEM hence is either unchanged, or slightly larger, compared to non-STEM programmes. Likewise, the gender balance within STEM does not appear to change. The decrease in the number of women in the 2005-09 cohort may be caused by the tendency that STEM programmes with many female students recruit students who have more gap years as compared to, for instance, the technical programmes that are dominated by males.

We did not find any clear changes in the distribution of students between the different types of STEM programmes. About 40% entered Science, about 20% university engineering and 30% professional engineering. In the third cohort, the proportion entering university engineering compared to professional engineering rose, but due to the gap year practice of Danish students the data concerning entering higher education in this cohort should be interpreted with caution.

While no discernible changes were found in the distribution of students between STEM and non-STEM programmes, there may be a slight change in the distribution of men and women between the different kinds of STEM programmes. Over the three cohorts, the share of female students tends to increase in Science and University engineering, while it seems to be decreasing in professional engineering, but the changes are small. The share of female students for the STEM programmes as a whole has been around 35% through the whole period. For Science is has been between 38% and 42%, for University engineering between 23% and 29% (the largest increase), and for professional engineering between 21% and 25%.

Finally, a multiple Cox analysis was conducted. This included interactional effects of gender on other variables. This analysis therefore examines whether some variables have a stronger effect for one gender than for the other, i.e. any indirect effect of gender differences. We found that the effects of the variables were stronger on women than on men. Concerning the ‘risk’ of a student choosing any STEM programme after gymnasium, this was increased for both genders with increasing educational level among parents, with higher GPA of the students, and for students who had attended ‘htx’, the technical branch of the gymnasium. However, if women, for instance, gained higher GPA than the reference person the risk of choosing a STEM course would increase more than would the same risk for a male student. In other words, female students appeared to be more affected by the achievements in gymnasium and by their parents’ educational background than their male peers. For students with high GPA and with highly educated parents the differences between the chances of men and women entering a STEM programme became smaller. This was not the case for university engineering where only attending the technical strand htx affected the chances of women entering more than it did men. The gender differences related to choosing university engineering are apparently more consistent than those related to university science or professional engineering.

Risks of non-completion

The focus in this section is on the factors that affect the risk of students not completing their STEM studies, and whether these factors affect men and women in different ways and to different extents.

According to previous research on student retention and non-completion there is no single, primary explanation for students not completing their programmes, and the findings concerning the effect of particular factors were inconclusive. Furthermore, there has been an increasing focus on issues of identity in relation to student transition and non-completion (see Chapter 13, Ulriksen, Madsen, and Holmegaard (2010), Holmegaard, Madsen, & Ulriksen, 2013). In his model of student departure, Vincent Tinto includes factors related to experiences at the higher-education institution and factors related to what he calls ‘pre-entry attributes’ such as family background and prior schooling (Tinto, 1993).

In this chapter we perform a quantitative analysis focusing on the pre-entry attributes. Even though this kind of analysis cannot uncover the reasons why certain factors appear to predict non-completion, it may draw attention to themes that from a macro level point of view appear to be significant.

Hence, this section seeks to answer the question of whether particular pre-entry attributes increase or decrease students’ risk of leaving their STEM programme without completing it and if there have been changes in the influence of these factors over time. We particularly focus on factors related to gender, that is, if factors affect the study course of men and women differently.

Methods

The analysis in this section considers 61,531 students who completed upper-secondary school between 1995 and 2007 and who went on to study at a STEM programme in higher education. Only students who left the programmes within the first three years after entry were included. Furthermore, we have only considered entry and departure from the first STEM programme. This means that students who have entered one STEM programme, left it, and then entered another are only included in the analysis in relation to the first STEM programme. Had the student entered a non-STEM programme, left it, and entered a STEM programme the student would be included in the analysis in relation to this STEM programme. Since the focus is on the students who leave their STEM study programme. We have omitted the group of students who completed upper-secondary school in 2008 and 2009 from the analysis, because a substantial proportion of these students will not have entered higher education before 2009, the last year for which we have data.

The gender distribution in the three cohorts is shown in Table 14.3.

Table 14.3 The number of students in the three cohorts and the gender distribution. All STEM programmes are included. The percentages refer to the distribution between men and women within STEM as a whole for each cohort.

Gender	Year of completing upper-secondary school					
	1995-1999		2000-2004		2005-2007	
	N	%	N	%	N	%
Men	16,433	65.8	14,940	65.0	8,608	63.4
Women	8,533	34.2	8,053	35.0	4,964	36.6
Total	24,966	100.0	22,993	100.0	13,572	100.0

A Kaplan-Meier estimate was calculated for the survival time of the students. The Kaplan-Meier estimate can be plotted as a curve to show the survival probabilities for the population. Every time someone from the population leaves the programme (i.e. no longer ‘survives’) a new survival estimate for the next student is calculated indicated by a small step at the curve. The estimate shows the cumulative risk of non-completion over time, but also the progression in student leaving.

Secondly, Cox analyses were performed. This is a method to calculate the hazard ratio for the survival of persons who have received a particular treatment compared to a reference person who did not receive the treatment. In this case, the treatment is the students’ possession of particular prognostic variables and the hazard ratio calculated thus expresses the relative risk of a student possessing one of those particular variables leaving the programme, compared to students without them. The reference person was defined as:

- Female
- Danish origin
- Parents with lower secondary school as the highest educational level (in other words, only compulsory schooling)
- Completed an stx (general upper-secondary school)
- Grade point average for the upper-secondary school exam below 6[3]
- No gap year
- No time spent at a previous higher-education programme

[3] According to the scale for grading, called the ’7-step scale’, students can be graded -3; 0; 2; 4; 7; 10; 12. To pass an exam students should have a GPA of 2 or higher. The grade 7 is considered the average level. This scale replaced another scale in 2007, but the GPAs of students graduating before 2007 have been converted to the 7-step scale. Achieving a GPA of 6 is therefore a bit below average, but not much. Between 21% and 26% of the students in the three cohorts belong to the group of GPA below 6.

– Living in a city

The analysis therefore expresses the change in relative risk for surviving (the hazard ratio) for, for example, a man compared to the reference person being a woman, or a student who completed an htx exam compared to the reference person completing an stx. The Cox analysis is a regression analysis calculating the relationship between a dependant variable (non-completion) and an independent variable (e.g., gender). The regression analysis was also carried out as a multiple regression where more than one variable were taken into consideration in calculating the hazard ratio. Finally, a multiple model was constructed to estimate the effect of gender on other variables. Does the GPA, for instance, affect choice and behaviour of women more or less than that of men or are there no differences?

In order to achieve a sufficient number of students in the different groups, the analyses were conducted for STEM programmes at sub-group level, including university engineering (a programme aiming at Masters level), professional engineering (a bachelor programme), university science (mainly aiming at Masters level), veterinary sciences (Masters level), architecture (Masters level) and a few others. However, the population in most of these programmes was too small to achieve statistically significant results. We therefore only present results for the STEM field in total and for the subgroups university science, university engineering and professional engineering.

Results (ii): Retention and non-completion

What is the risk of non-completion?

The proportion of students who left the first STEM higher education programme they entered within three years of upper-secondary schooling has been decreasing, especially for the 2005-07 cohort. Whereas 30% left within the first three years for the group of students leaving upper-secondary school in 1995-99 only 23% of the 2005-07 cohort did the same (Table 14.4). This result for the most recent cohort should be regarded with some caution because the group of students included in this number are mainly those who enter immediately after finishing upper-secondary school. However, even if the completion rate of the most recent cohort is an overestimate, the decreasing non-completion rate is in accordance with statistics from the Danish Ministry of Science, Innovation and Higher Education (Universitets- og Bygningsstyrelsen, 2011).

Table 14.4 shows that while STEM programmes in total suffer from higher non-completion rates than non-STEM programmes, there are also variations within each field. Within STEM, university science programmes have higher non-completion rates than the engineering programmes. The most successful programmes in retaining students are university health and veterinary science programmes at universities.

Table 14.4. The percentage of students who within 3 years of entering a university programme leave it without completing, for STEM and non-STEM programmes in total, and for selected programmes within STEM and non-STEM (percentage of the cohorts)

	First opt-out within 3 years (%)									
	STEM programmes						Non-STEM programmes			
	STEM (total)	University science	University engineering	Professional engineering	Architecture	Veterinary science	Non-STEM (total)	University health	University social sciences	Univeristy humanities
1995-1999	29.8	37.9	25.0	29.9	18.7	10.2	25.6	14.4	27.9	38.4
2000-2004	28.7	33.5	24.9	29.8	18.0	9.9	26.2	14.3	27.9	35.3
2005-2007	22.6	25.7	22.0	20.4	15.8	4.7	20.3	10.0	20.9	24.5

Time from access to departure from the programmes

Kaplan-Meier curves were estimated showing the cumulative percentage of students having left the programme in first 36 months. About half the students who departed during the first three years did so within the first year. Another 25% to 30% of the students not completing left during the second year and between 20% and 30% during the third. Student departure occurred throughout the entire three-year period with the transition between years as noticeable peaks (Figure 14.1).

These results suggest that even if the first year of study is an important period in the retention of students it is by no means the only time during the study where the programmes are in danger of losing their students. When comparing the Kaplan-Meier curves for the three cohorts we found no clear trend of change in the pattern concerning when students left the programmes.

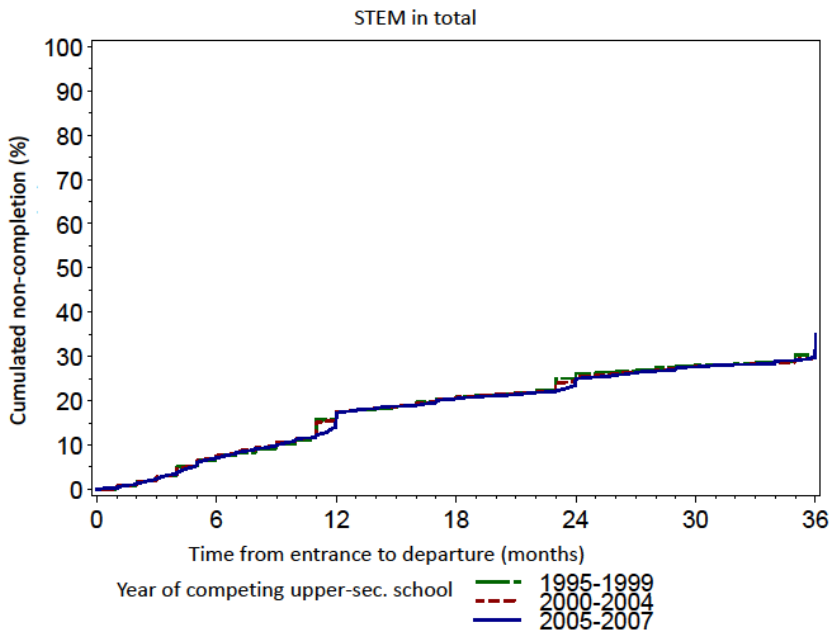


Fig. 14.1 Kaplan-Meier curve for STEM total showing the cumulated departure (%) and the time from entrance to departure (months) for the three cohorts

Factors influencing the risk of not completing a STEM programme

The results of the simple and the multiple Cox analyses are presented in Table 14.5. The Cox analyses show that the grade-point average (GPA) from upper-secondary school and the parents' educational background were most strongly related to an increased retention on STEM programmes. Higher GPA reduced the risk of non-completion. This was the case for STEM in total and for the three individual groups of studies (science, university engineering and professional engineering).

Table 14.5 Selected results of the simple and multiple Cox analysis. Selected variables. ns=no significant difference in hazard ratio compared to reference person. More results can be found in Table 14.9. Numbers refer to the relative risk of not completing a STEM education for a student possessing particular attributes compared to the reference person. Hazard ratios below 1 signify that the a student possessing the particular attribute indicated in the left column is MORE likely than the reference person to complete the education; hazard ratios above 1 mean that the student is LESS likely than the reference person to complete.

Estimate of relative risk of non-completion						
	Simple			**Multiple**		
Gender	1995-99	2000-04	2005-09	1995-99	2000-04	2005-09
STEM	ns	0.902	0.843	0.898	0.804	0.81
Science	1.089	ns	ns	ns	0.846	0.81
University Engineering	ns	ns	ns	0.866	0.858	ns
Professional Engineering	ns	ns	ns	0.886	0.884	ns
Parental education – Masters level (LVU)						
STEM	0.584	0.524	0.625	0.741	0.705	ns
Science	0.555	0.485	0.668	0.752	0.714	ns
University Engineering	0.591	0.589	0.677	0.763	0.761	ns
Professional Engineering	0.802	0.712	ns	ns	0.784	ns
GPA – upper-secondary school higher than 8						
STEM	0.45	0.416	0.389	0.421	0.406	0.543
Science	0.448	0.379	0.399	0.429	0.388	0.55
University Engineering	0.394	0.4	0.36	0.404	0.376	ns
Professional Engineering	0.514	0.468	0.459	0.481	0.437	0.479
One gap year						
STEM	0.883	0.888	0.899	0.909	0.881	0.810
Science	ns	0.812	ns	ns	0.860	ns
University Engineering	ns	ns	ns	ns	0.834	0.804
Professional Engineering	ns	ns	ns	0.865	0.865	ns

The effect of the parents' educational background was also clear and substantial, but mainly if the parents had completed a higher education. For some groups, particularly in engineering, there was no statistically significant difference in hazard ratio between students whose parents had no education expect for lower-secondary school (the reference person) and students whose parents had vocational training or (for civil engineering) shorter period higher education of up to two years duration. In other words, the decisive feature appears to be whether the parents have attended a university or professional bachelors programme or not.

A second variable with some effect on the hazard ratio was whether there was a time gap between the completion of upper-secondary school and entering the STEM programme taken as a whole. In most cases, having a break reduced the risk of leaving the programme, and the longer the break, the stronger the effect. For some cohorts the effect was only significant for some time gaps and not for others (e.g., for university engineering students in the 2000-04 cohort). For the 2005-07 cohort the effect was less pronounced, but still present for the group of STEM students as a whole. However, we found a converse effect of having a two or five year gap for university engineering students in the 1995-99 cohort. For those students that particular gap increased the risk of leaving.

The effects of gender on the hazard ratio

Concerning gender, the simple Cox analysis found an increased risk of non-completion for women in STEM as a whole for the cohorts 2000-04 (HR=0.90) and 2005-07 (HR=0.84). There was no significant difference for the 1995-99 cohort. For science programmes we found that for the 1995-99 cohort men showed an increased risk of non-completion, with no significant gender-related differences for the two following cohorts. In the case of both types of engineering programmes there were no significant differences in the hazard ratios for men and women in any of the three cohorts. Hence, the simple Cox analysis suggests that the there is no significant difference in the risk of non-completion related to gender.

This pattern changed in the multiple Cox analysis. For the first cohort (1995-99) men had a significantly lower risk of leaving the programmes than women, except in science where there was no significant difference. In the second cohort (2000-04) there was a significant difference for both STEM and the three individual programmes. In the most recent cohort (2005-07) the effect of gender was significant for STEM as a whole and for science, but not for the two kinds of engineering programmes.

It therefore appears as if gender indeed has a significant effect in itself since the difference was more pronounced in the multiple analyses where other variables were taken into account. These other components (e.g., the average GPA of men and women) could obscure the gender effect in the simple analyses, but the multiple analyses indicate that there are significant differences in the risk of non-completion for men and women. However, the hazard ratios of between 0.8 and

0.9 are smaller than those related to, for example, parents' educational level. Gender, it appears, is one factor affecting persistence, but not the most significant one.

In the analysis of whether particular variables affected men and women differently, we found very limited differences. Attendance at the technical gymnasium (htx) did affect the hazard ratio of men and women differently. Male students who had attended htx reduced their risk of non-completion more than did women. However, the effect of htx in itself varied between programmes and across the different cohorts. Furthermore, the varied effect of htx over time may be due to changes in the structure and the position of this particular kind of gymnasium in the 15 years in question. These results are therefore less interesting because it is difficult to interpret any clear direction in the results.

The second variable that affected men and women differently was the GPA for STEM as a whole. This was only significant for the 2000-04 cohort and not in the analyses at the level of university science or the engineering programmes. It was found that the risk of not completing was reduced more for female than for male students who had a GPA of between 6 and 7 compared to the reference person who had a GPA of 6 or less. However, for students with a GPA between 7 and 8, and of 8 or higher, it had a stronger impact on the male than on female students. In other words, there does not seem to be a consistent difference in the impact of GPA on men and women.

Overall, there do not appear to be any noteworthy significant differences as to how variables affect the non-completion risk of men and women.

Results (iii): Departure trajectories

The final analysis carried out on the data was to see where students went after having left their higher-education study programme. Tinto (1993) distinguishes between programme departure and institutional departure. Institutional departure refers to students who leave college without entering another programme, whereas programme departure refers to students who leave one programme or college to enter another. From a societal perspective the institutional departure therefore calls for more concern than does the programme departure, because the students who merely change programme still complete a degree.

In an IRIS context, we have a more specific interest in whether students who leave a STEM programme enter another STEM programme or not. We therefore talk of STEM departures as opposed to changes between STEM programmes (programme departures) or students not entering another programme (institutional departure). That is the focus of this section.

The first part of the analysis includes descriptive data where we have tracked the path taken by students who opted out of a programme. Kaplan-Meier curves were made estimating the time from departure to entrance to a new programme within the first three years after leaving the STEM programme. Finally, both simple and multiple Cox analyses were carried out calculating the hazard ratio for entering a STEM programme after leaving one. In order to have sufficient number of students to be able to make the analyses, the Cox analyses consider transition to a STEM programme (including veterinary sciences) or a non-STEM programme.

Where do students go after leaving STEM?

The results concern in total 18,209 students who in the period 1995-2007 within the first three years of study left the first STEM programme they enrolled on. Table 14.6 and Table 14.7 show where the students went after leaving their first STEM programme (Table 14.6) or non-STEM programme (Table 14.7). Table 14.6 shows that approximately one fifth of the STEM students experienced an institutional departure. The number of institutional departures is increasing slightly, but the students in the 2005-07 cohort have had a shorter time to enter another programme, and the change for this cohort should therefore be interpreted with caution. Another group entered either vocational training or a two-year higher education programme (KVU). This was the case for one out of six in 1995-99, but this group has diminished over the three cohorts, down to one in eight.

Furthermore, one third of the students who left a STEM higher education programme re-entered a non-STEM higher education bachelors or Masters programme – virtually the same share changed from one STEM programme to another. In 1995-99, 31.8 % re-entered a STEM programme while 32.2 % went to a non-STEM higher-education programme. In 2000-04, it was 30.5 % to STEM and 35.5 % for non-STEM programmes. In the 2005-07 cohort, the STEM and non-STEM re-entry was the same: 32.5 %. In summary, approximately one third of the STEM students leaving their programme were institutional departures, but two thirds were STEM departures.

Table 14.6 Transition pattern of STEM students after leaving their first STEM programme

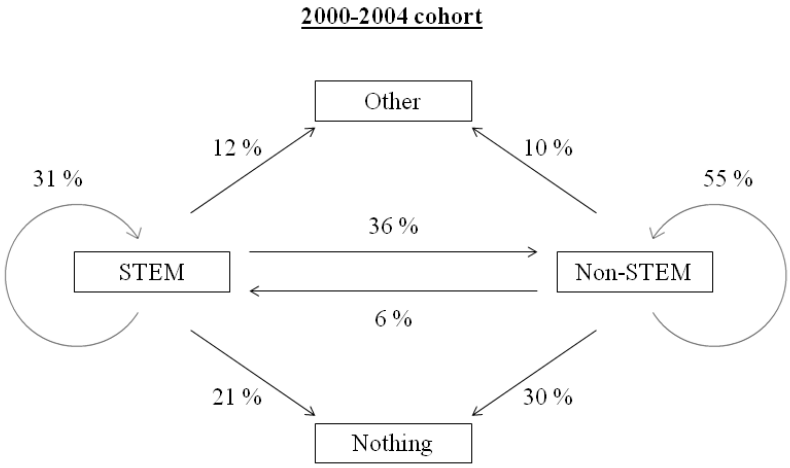
Transition to:	Year of completing upper-secondary school					
	1995-1999		2000-2004		2005-2007	
	N	%	N	%	N	%
None	1615	19,8	1457	20,7	668	22,3
Science, Math	1055	12,9	746	10,6	379	12,6
Veterinary sc	260	3,2	162	2,3	78	2,6
Tech, engineering	1279	15,7	1239	17,6	516	17,2
Non-STEM	2628	32,2	2500	35,5	975	32,5
Vocational training or 2-year higher education	1317	16,1	829	11,8	372	12,4
PhD	15	0,2	109	1,5	10	0,3
Total	8169	100,0	7042	100,0	2998	100,0

Table 14.7 Transition pattern of non-STEM students after leaving their non-STEM programmes

Transition to:	Year of completing upper-secondary school					
	1995-1999		2000-2004		2005-2007	
	N	%	N	%	N	%
None	7984	29,5	7245	29,6	3540	35,2
Science, Math	721	2,7	655	2,7	268	2,7
Veterinary sc	102	0,4	88	0,4	58	0,6
Tech, engineering	597	2,2	576	2,4	285	2,8
Non-STEM	15117	55,8	13472	55,0	4922	48,9
Vocational training or 2-year higher education	2528	9,3	2397	9,8	985	9,8
PhD	27	0,1	63	0,3	0	0
Total	27076	100,0	24496	100,0	10058	100,0

he trajectories of students leaving non-STEM programmes display a different picture. About half the students (a little fewer in the 2005-07cohort) continue on to another non-STEM bachelors or Masters programme. Between 40% and 45% of the students move on to something else – the largest group of about 30% leaves the educational system. Finally, only five or six percent enter a STEM programme. Most of these come from university bachelor programmes in social sciences or humanities, but the group of non-STEM programmes with the highest percentage of leavers moving to STEM is the university programmes in health (medicine, pharmacy, etc.).

From the point of view of there being too few graduates within STEM these are disturbing results. They reveal a net loss of students from STEM to non-STEM programmes (Figure 14.2). Even though the non-STEM label in this context refers to a very broad group of programmes including health, it still means that when STEM programmes lose students two-third of them are STEM departures. Therefore it appears to be highly important for the STEM programmes to put even more



focus on holding on to the students who decided to enter a STEM higher-education programme in the first place.

Fig. 14.2 Transition patterns for students in cohort 2000-04 leaving their first STEM programme.

Time gap between leaving one programme and entering another

Kaplan-Meier curves for the time passing between leaving one STEM programme and entering another STEM programme show that for STEM as a whole just over half of the students begin at another STEM programme immediately after leaving (that is, within one or two months). The remaining half of those re-entering a STEM programme within three years enrol at another programme at a constant rate. When looking at the individual programmes this picture changes a little. It appears that the change for the two larger groups (science and university engineering) has a steady flow to other programmes, but after two years this fades and the curve becomes flatter with fewer entering another programme. For professional engineering this flattening appears after one year. Overall, it seems that most of those students who enter another STEM programme after leaving the first do so within the first two years.

Factors affecting the choice of STEM after leaving a STEM programme

We now examine the multiple Cox analyses concerning which factors affect the inclination of the students who leave the first STEM programme they enter to move on to a STEM programme or a non-STEM programme. Once again we find that GPA from upper-secondary school consistently has a significant effect, but the effect is present both for entering STEM and non-STEM. This means that the GPA from upper-secondary school affects the inclination to enter any programme after leaving, irrespective of the second programme. However, students with a GPA above 8 were notably more likely to re-enter a non-STEM programme compared with re-entering a STEM programme (hazard ratio 2,05 for non-STEM compared to 1,65 for STEM). This could be due to the Danish system of admittance where the selection of students is based on GPA. Most of the STEM programmes have fewer applicants than the number they can admit meaning that there is no GPA-based selection on these programmes. Conversely, many programmes within health and the social sciences have more applicants than they can admit. Consequently, students with a GPA below a given threshold (this varies every year according to the number of students applying and the GPA of the last student admitted that particular year) are rejected. The higher hazard ratio of students with a GPA above 8 may therefore not reflect the fact that students with higher GPA are more inclined to apply for non-STEM programmes than students with lower GPA, but simply that the latter are not accepted at the non-STEM programmes and therefore ‘choose’ to re-enter a STEM programme.

As for parents’ highest education this has an impact on the hazard ratio for both STEM and non-STEM programmes in the 1995-99 cohort. In the 2000-04 cohort parental educational level only has a significant effect for choosing STEM programmes, but not for non-STEM programmes. Students whose parents have completed a higher education programme are more likely to re-enter a STEM programme than students with parents without higher education.

Gender is significant for all cohorts. Being male significantly increases the risk of choosing STEM and decreases the risk of choosing non-STEM. However, the effect is stronger in relation to non-STEM programmes. That is, the difference in the relative risk of men and women is larger for non-STEM programmes than for STEM programmes. This means, that even among students who initially entered a STEM programme we found gender differences in the inclination to re-enter a

STEM programme. Compared to the differences between the risk of men and women for choosing STEM in the first place, the difference is substantially smaller, but still significant (Table 14.8).

Table 14.8 The relative risk of men as compared to that of women for choosing a STEM programme after upper-secondary school and after leaving a STEM programme. The last cohort covers different time span (five vs three years).

	Hazard ratio for men	
	Choosing STEM after upper-secondary school	Choosing STEM after leaving a STEM programme
1995-99	2.66	1.09
2000-04	2.51	1.30
2005-09/07	2.21	1.19

Discussion

This chapter addressed three questions. All of these were scrutinised in a Danish context with Danish data.

Recruitment

The first question concerned whether, alongside the substantial focus in research, policy documents, and recruitment initiatives on gender imbalances in STEM programmes, there were any changes in the patterns of choice of men and women when deciding which higher-education programme to enter. This does not appear to be the case. The share of students entering STEM programmes appears to have remained stable from 1995 to 2009, as has the gender balance. Apparently, the focus on increasing the intake of students in general and of female students in particular has had little effect.

Retention

The second question focussed on retention and non-completion. Firstly, we found a substantial increase in retention within STEM in total and within the different types of programmes. This is encouraging. Still, one in four students who enters a university science programme leaves it within three years without completion. For STEM as a whole this is more than one in five. However, these high non-completion rates are not unique to STEM and may be a generic challenge for the higher-education system as a whole rather than specific to individual programmes.

On the other hand, the differences between the programmes suggest that there are reasons to delve further into the decisions of STEM students leaving their programme before completion. The present analysis allows only for a limited scrutiny of the reasons for the students' non-completion, and only for those factors that relate to what is labelled 'pre-entry qualifications' in Tinto's model. The analysis showed that prior school attainment had the strongest effect on persistence with increasing GPA related to increasing persistence. This could explain some of the variations between the non-completion rates within the STEM programmes.

The highest persistence rates were found in the veterinary sciences and architecture. These programmes are highly selective requiring students to have obtained an overall GPA of 9 or more to gain access. With GPA as the most important predictors of persistence it is not surprising that these competitive programmes succeed in holding on to more students. On the other hand, the variance in the proportion of students leaving these programmes (ranging from 5% to 16%) suggests that there are other elements affecting retention than merely the students' prior academic achievements.

The effect of the parental educational level that we found has been firmly established in a number of other studies (cf. Pascarella and Terenzini (2005)). However, we also found that the effect of parental education was not in all cases significant below bachelors level. Furthermore, we noted that the effect size was similar for the first and the second cohorts, but for the third cohort the effect diminished or disappeared. It is unlikely that these results can be interpreted as if equal opportunities now exist for all students, regardless of social background. On the other hand, the results may indicate a development that warrants further investigation.

Finally, there is some evidence suggesting that the students' social background has a larger impact on the non-completion rates in the sciences than in engineering. Particularly, it seems that social background has less importance for students in professional engineering than in the other fields. It is not possible, using the data in this study, to explain why.

Turning to the effect of gender on persistence, we found that while there were few significant effects of gender on the risk of non-completion in the simple Cox analysis, the picture changed in the multiple Cox analysis where a model has been constructed including more than one variable. In the multiple Cox analysis, we found increased risks of non-completion for women in all cohorts, where there were none in the simple Cox analysis. This suggests that even if it appears as if women are not more at risk for dropping out it turns out that they are when other variables are taken into account. This could indicate that some of the conditions students are meeting within the programmes are more hazardous to women than to men.

Overall, we found effects of factors related to pre-entry qualifications. In an IRIS context, the increased risk of women of leaving their STEM programme without completing calls for concern, not least because it appears as if there are features related to gender itself that are of importance. It would require a qualitative approach to establish which features these could be. Chapter 19 on gender-biased programmes provides an example of such an approach.

The Kaplan-Meier analysis shows that even though half of the students who left their programmes did so within the first 12 months, another half left later. Attempts to reduce student non-completion therefore need to look further than the first year of study. Some of the students who left the programme beyond the first year may not have passed enough courses to make up one year of study as measured by the number of ECTS points passed, but they still survived the first year and moved on to the second and third year. We may therefore fail to approach students with difficulties in completing their university studies if we confine our efforts to the students first year of study. This draws attention to the need to address first and second year experiences (as pointed out in the literature review, Chapter 13).

Departure trajectories

The results concerning departure trajectories are truly worrying because they reveal a substantial loss of STEM students. While students from non-STEM programmes tend to remain within non-STEM programmes (albeit, in this analysis a very mixed group of programmes) only one third of the STEM students opting out decide to re-enter a STEM programme. This suggests that the endeavour to make students who enter a STEM programme stay is highly important if the goal is to increase the number of graduates within STEM.

The Kaplan-Meier analyses indicated that students do not leave one programme to enter another immediately after, but, on the other hand, most of the students enter a new programme within the first two years after leaving the first STEM programme. The time gap between leaving and entering may be an indication that the choice of leaving is not necessarily a decision *for* something different, but just as much a decision *away* from the programme first entered.

The third – and also disturbing – point relates to the gender differences in the students' choice of a new study after having left a STEM programme. When students make their first choice after upper-secondary school there is a clear gender difference in the patterns of choice with men being far more inclined to choose a STEM programme than women. However, it is surprising that there is also a gender difference among the students who chose a STEM programme as their first course of study, but then left the programme and entered another. Even in this group of original STEM choosers men are more inclined to enter another STEM programme than women. The gender difference is smaller by the second choice than by the first, but there is still a significant difference. This means that even after the students had decided to pursue a STEM study path at the first point of decision, the gender difference persisted by the second point of decision. The gender imbalance hence increases in two ways when students leave the first STEM programme they entered: firstly, because women have a higher risk of not completing; secondly, because more men than women re-enter a STEM programme.

Conclusion

The results from the analysis of Danish national data reported in this chapter show that the patterns of choice change slowly and very little, both in relation to STEM as a whole and to increasing the number of women entering STEM. In spite of considerable attention over more than a decade, the numbers of STEM applicants have changed very little. On the other hand, the results show that it has been possible to improve the retention rates over time, even though the number of students not completing the programme they enter is still alarmingly high. Furthermore, we found that the pre-entry factors already known to affect retention, namely prior school attainment and the parents' educational background still have a strong impact on the students' risk of non-completion.

However, what we consider the most worrying conclusion to be drawn is the large STEM departure in the departure trajectories combined with an almost non-existing influx of students departing from non-STEM programmes. This means that efforts to hold on to students who initially enter a STEM higher education programme are very important. Such efforts are, perhaps, even more important than recruitment initiatives. Furthermore, the gender imbalance is increased in the process of leaving and re-entering since women to a larger extent seek to move away from the STEM programmes as compared to men.

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Table 14.9 Selected results from the multiple Cox analysis. *=p<0,05; **=p<0,01; ***=p<0,0001; Un.Eng.= university engineering; pr.eng.=professional engineering; Parents 2y HE=parents highest education 2 years HE cycle (=KVU); Parents 3y HE=parents high.

	Cohorts – year of completing upper-secondary school											
	1995-99				**2000-04**				**2005-07**			
	STEM	SCI-ENCE	UN. ENG.	PR. ENG	STEM	SCI-ENCE	UN. ENG.	PR. ENG	STEM	SCI-ENCE	UN. ENG.	PR.ENG
Male	0,898**	n.s.	0,866*	0,886*	0,804***	0,846***	0,858*	0,884*	0,810***	0,810**	n.s.	n.s.
Parents 2y HE	0,841*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Parents 3y HE	0,808***	0,875*	0,779*	n.s.	0,768***	0,785**	n.s.	0,795*	n.s.	n.s.	n.s.	n.s.
Parents 5y HE	0,741***	0,752**	0,763*	n.s.	0,705***	0,714***	0,761*	0,784*	n.s.	n.s.	n.s.	n.s.
GPA 6-7	0,680***	0,736***	n.s.	0,623***	0,665***	0,694***	0,792*	0,625***	0,768**	0,75 8**	n.s.	0,567***
GPA 7-8	0,565***	0,655***	0,644***	0,532***	0,567***	0,561***	0,614***	0,570***	0,697***	0,747**	n.s.	0,531**
GPA 8+	0,421***	0,429***	0,404***	0,481***	0,406***	0,388***	0,376***	0,437***	0,543***	0,550***	n.s.	0,479**
1 gap year	0,909*	n.s.	n.s.	0,865*	0,881**	0,860**	0,834*	0,865*	0,810***	n.s.	0,804*	n.s.
2 gap years	0,913*	n.s.	1,212*	0,806**	0,776***	0,767***	n.s.	0,831*	0,789**	n.s.	n.s.	n.s.
3 gap years	0,755***	0,768**	n.s.	0,777**	0,747***	0,704***	n.s.	0,724**	0,600**	n.s.	n.s.	0,543*
4 gap years	0,678**	0,706**	n.s.	0,692**	0,673***	0,682**	0,649*	0,560***	-	-	-	-
5 gap years	0,561***	0,602***	1,715**	0,563***	0,575***	0,610**	n.s.	0,620**	-	-	-	-
1 y prior HE	n.s.	n.s.	n.s.	n.s.	n.s.	0,746**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
2 y prior HE	1,241**	n.s.	0,485**	n.s.	1,287**	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
3 y prior HE	n.s.	1,434**	0,335***	1,396*	n.s.	n.s.	n.s.	n.s.	-	-	-	-
4 y prior HE	n.s.	n.s.	0,380**	1,897**	n.s.	n.s.	n.s.	n.s.	-	-	-	-
5 y prior HE	n.s.	n.s.	n.s.	2,520***	n.s.	n.s.	n.s.	n.s.	-	-	-	-